Resource Choices and the Environment

CONCEPT: Now that students have the basic building blocks, this lesson introduces them to a wider variety of methods of producing and conserving electric power. As we learned in the last lesson, environmental consequences of resources need to be taken into account. Challenge students to decide which resources they would choose for the Northwest.

DIRECTIONS: Have students add detail to their designs developed in lessons 10 and 11. They can also illustrate new methods introduced in this lesson. Appendix C contains more detailed descriptions and diagrams of these resources that can be accessed by students as reference materials. Ask the students to include environmental consequences for the resources in their designs. Students can locate Northwest coal, nuclear, and gas fired electric plants on the Electric Power Plants in the Pacific Northwest map.

For older students, groups may be assigned the task of researching a particular resource type and presenting it to the class along with a recommendation as to whether that resource should be pursued. The reference materials in Appendix C are a good first place to look. Encyclopedias often have much to offer under topics such as turbine, nuclear energy, coal, wind, solar - energy, etc.

USING WATER TO PUSH THE TURBINE: Begin by introducing the Greek word for water, "hydro". Hydropower uses the energy of falling water to power turbines. It is a major source of power in the Northwest. Ask how many students designed a water wheel turbine under a dam or waterfall. Can the students figure out the two most important factors affecting the power available from a hydro project (the amount of water available, and the pressure or height of the falling water)? Is water both the fuel and the working fluid? Challenge the students to explain where the energy comes from for all that falling water.

One important aspect of hydropower in the Northwest is that the best hydro sites have been taken. Can the students explain why putting more dams on the rivers near where there are already dams won't produce much additional power?

Environmental Considerations

Ask the students to review the environmental considerations related to hydropower—obstruction to fish, availability of irrigation water for crops, flooding of large amounts of riparian land, temperature changes for fish, concentration of fish (at inlets and outlets of passage facilities) for predators, etc. Allow students to work as a group to come up with as

Watts, Kilowatts, and Megawatts

1 Watt	About the power it takes to lift one apple every second from the floor to a countertop.
1 Kilowatt (kw) = 1,000 watts	The power consumed by a typical hair dryer. It is the power output of a 1.34 horsepower engine. US households use energy at an average rate of 1 kw. It is the same as lifting a thousand apples to a countertop every second.
1 Megawatt (MW) = 1 million watts	The average power used by 1,000 US households. It is also the power consumed by 1,000 hair dryers at once.
1,000 Megawatts = 1 Gigawatt (GW)	The output of the very largest coal and nuclear plants. The average power production in the Northwest is about 20,000 MW (20 GW).

NOTE: The total amount of energy produced or consumed depends on how long the power is turned on. For example, one kilowatt-hour (kwh) is equivalent to leaving a hair dryer on for one hour.

many factors as they can. Have them include at least some of them in their drawings. How will they design their hydro projects to reduce environmental problems?

USING AIR TO PUSH THE TURBINE: Placing turbines on high towers to catch the energy in the wind is another way to produce electricity. Have students try to design their own turbine shapes for their wind power plants. A wide variety of shapes have been tried. Interested students can compare their designs with those in use. Encourage them to build and test their own designs. Where does the energy in the wind come from? Do student know what fuel powers the wind? The sun's energy creates the wind and lifts water for hydropower. The fuel for this immense influx of energy to the earth is the very mass of the sun itself, being converted by nuclear processes within the sun to sunlight.

Environmental Considerations

Harnessing wind can change the look of a landscape, cause localized noise problems, and pose a threat to birds and aircraft. Many wind sites are far from where electricity is needed, making it necessary to build long transmission lines through often pristine areas of the Northwest. How will the students account for these effects in their designs?

USING COMBUSTION GASES TO PUSH THE TURBINE: An increasingly common form of electric power generation uses the exhaust from burning fuel to push directly against turbine blades. This technology is used to power jet aircraft. The simplest example of these combustion turbines is the Christmas toy consisting of a metal fan blade suspended over a few candles. The hot exhaust from the burning candles pushes past the turbine blades.

Environmental Considerations

Combustion turbines for producing power usually burn natural gas. Natural gas is the cleanest burning fossil fuel. Combustion turbines are also among the most efficient means of converting energy from fossil fuels to electric power. Their efficiency is boosted when the exhaust from the turbine is recycled to boil water and push a separate steam turbine. While combustion turbines are a relatively clean source of electric power, they do produce carbon dioxide— thought to contribute to global warming, and nitrogen oxides that contribute to local smog and acid rain.

USING STEAM TO PUSH THE TURBINE: Most of the resource choices we are familiar with involve pushing a turbine with steam. The differences among these resources is in what fuel is used to produce steam. If coal is burned to heat water in a boiler, then it is a coal plant. If the heat from splitting atoms is used, then it is a nuclear plant. Oil and natural gas can also be used.

Wood, or other biomass fuel can be burned to boil water as well. Sunlight, concentrated by mirrors, produces steam in solar power plants (the largest solar plants use natural gas as supplementary and backup fuel). Another way of producing electricity from sunlight without steam or turbines is discussed below.

Heat from the earth can also be used to produce steam. Geothermal power plants can sometimes make use of hot rocks under ground by digging wells and pushing water down to be heated. At some sites, steam is available directly, sometimes indicated by the presence of geysers.

By far, most of the electricity generated in the United States is generated from steam turbines powered by coal, nuclear, oil, and natural gas.

Environmental Considerations

See Appendix C for more detailed discussions of the environmental considerations for these resources. One common need all steam power plants have is a source of water. Water is used to produce the steam and usually for cooling (cooling is necessary for efficient operation of steam plants). Steam plants all release large amounts of waste heat to the environment. If the heat is rejected to streams, aquatic life may suffer. Released to the air, micro climates around the plant may be affected.

Students will be familiar with many of the environmental concerns regarding the more common steam power plants. Have them hypothesize what the concerns for biomass, solar, and geothermal might be. The students need to include some representation of these concerns, and potential means of dealing with them in their designs.

ELECTRICITY - NO TURBINES, NO MAGNETS, NO MOVING PARTS: Another way to produce electricity from the sun is with thin wafers that convert sunlight directly with no moving parts. These wafers, called **photovoltaics,** are made of the same material as computer chips. Photovoltaics are typically made up of two materials, a very thin surface material, and a thicker base material. Light particles pass through the thin surface material and collide with electrons in the base material. Electrons are knocked into the surface material and collected by thin wires there. A voltage appears between the surface wires and the base wires when sunlight falls on the surface.

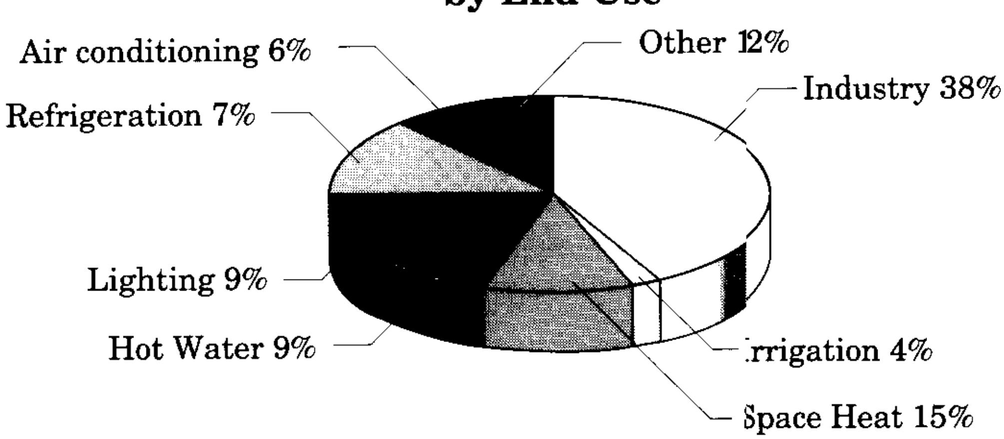
Environmental Considerations

Manufacturing photovoltaic materials has the same environmental effects as the computer chip industry. This industry relies on some powerful chemicals to produce the wafers. Usually the effluents can be contained. Photovoltaics will require relatively large areas of sunny land. The sunniest regions of the Northwest tend to be fairly isolated areas, necessitating long transmission corridors to take the power to the load centers. The best sites in the Northwest (Southeast Oregon) get only 75% of the solar energy that falls on parts of California and Nevada. Power lines will be needed to take this energy to the more populated parts of the Northwest.

USE LESS - CONSERVATION: Electricity is used for producing light, heating homes and water, processing aluminum and other metals, running motors, etc. When devices that convert electricity to these useful purposes are made to use less, more is available for others to use. Making smarter use of electricity is a source ofpower for new users. Conservation of electricity can be a very clean and inexpensive way of meeting demands for more power. There are no turbines, no fuels to burn. There can beenvironmental consequences from conservation measures. For example, some Styrofoam insulation used for insulating concrete foundations contributes to degradation of the ozone layer. Making houses more airtight to keep out the cold (or heat) can result in poor air quality in the home.

Conservation Exercise: Have students use the Pacific Northwest Loads by End-Use chart to calculate the energy savings from reducing industrial consumption by 10% (38% X 20,600 = 7,828 MW : 10% X 7,288 = 728 MW. This is about the output of the WNP 2 nuclear reactor on the Hanford Reservation).

Pacific Northwest Loads by End-Use



Total Load (1992) = 20,600 Average Megawatts

Fuel Switching: Some planners suggest that hot water and buildings could be more efficiently heated with gas or oil than with electricity. Switching from electricity to other fuels that provide the same service as a way to conserve electricity is called "fuel switching." Use the chart below to calculate how many megawatts are used for heating hot water and buildings (9%+15%=24%. 24% X 20,600= 4,900 megawatts). Suppose that 10% of the electrical hot water and space heat loads were converted to natural gas or other fuels. How much electricity would be saved? (10% X 4,900 = 490 megawatts).

Conservation Lab: This is a design challenge for students to experiment with conserving energy. Give groups of three students a paper or plastic cup along with a variety of other materials (paper, plastic wrap, aluminum foil, tape). The teams are to design a jacket for their cups. When they have completed their designs, the class can hold a competition to see whose design works the best. Put a thermometer into the cups and pour warm water from a single pitcher into them. Wait at least twenty minutes before checking them.